

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

REC'D 04 JUN 1999

WIPO PCT

Applicant's or agent's file reference P 98-029 LK/uh	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/SE98/00170	International filing date (day/month/year) 02.02.1998	Priority date (day/month/year) 03.02.1997
International Patent Classification (IPC) or national classification and IPC ₆ H02K 15/085		
Applicant ASEA BROWN BOVERI AB et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.
- ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of _____ sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☐ Certain observations on the international application

Date of submission of the demand 31.08.1998	Date of completion of this report 05.05.1999
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. 08-667 72 88	Authorized officer Håkan Sandh/itw Telephone No. 08-782 25 00

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE98/00170

I. Basis of the report

1. This report has been drawn on the basis of *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments.)*:

- ☒ the international application as originally filed.
- ☐ the description, pages _____, as originally filed,
 pages _____, filed with the demand,
 pages _____, filed with the letter of _____,
 pages _____, filed with the letter of _____.
- ☐ the claims, Nos. _____, as originally filed,
 Nos. _____, as amended under Article 19,
 Nos. _____, filed with the demand,
 Nos. _____, filed with the letter of _____,
 Nos. _____, filed with the letter of _____.
- ☐ the drawings, sheets/fig _____, as originally filed,
 sheets/fig _____, filed with the demand
 sheets/fig _____, filed with the letter of _____,
 sheets/fig _____, filed with the letter of _____.

2. The amendments have resulted in the cancellation of:

- ☐ the description, pages _____
- ☐ the claims, Nos. _____
- ☐ the drawings, sheets/fig _____

3. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE98/00170

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	<u>1-21</u>	YES
	Claims		NO
Inventive step (IS)	Claims	<u>1-21</u>	YES
	Claims		NO
Industrial applicability (IA)	Claims	<u>1-21</u>	YES
	Claims		NO

2. Citations and explanations

The invention relates to a rotating electric machine comprising a stator with windings drawn through slots in the stator and a method for manufacturing such a machine. According to the invention the windings consist of high-voltage cable and to prevent damage to the cable during drawing through the slots and during operation the slots are at the end surface provided with cuff means extending axially a short distance into the slots.

Documents cited in the International Search Report:

US 3130335
US 3943392
DE 4023903
US 5036165
US 4853565
US 4510077
SU 955369

The prior art documents disclose rotating electric machines comprising a stator having slots for the windings. The slots are provided with linings. However, none of the documents shows a rotating electric machine with windings consisting of high-voltage cable drawn through the slots and the slots being provided with a cuff at the end surface as defined in the claims. Since there is no teaching in the prior art that would lead a skilled person to the invention, the claimed invention is not considered obvious.

Accordingly, the claimed invention is novel and considered to involve an inventive step. The invention is industrially applicable.

PATENT COOPERATION TREATY

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NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

United States Patent and Trademark
Office
(Box PCT)
Crystal Plaza 2
Washington, DC 20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 22 September 1998 (22.09.98)	
International application No. PCT/SE98/00170	Applicant's or agent's file reference P 98-029/LK
International filing date (day/month/year) 02 February 1998 (02.02.98)	Priority date (day/month/year) 03 February 1997 (03.02.97)
Applicant HOLMSTRÖM, Göran et al	

1. The designated Office is hereby notified of its election made:



in the demand filed with the International Preliminary Examining Authority on:

31 August 1998 (31.08.98)



in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer

A. Karkachi

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY EXAMINATION REPORT

Applicant's or agent's file reference P 98-029 LK/uh	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/SE98/00170	International filing date (day/month/year) 02.02.1998	Priority date (day/month/year) 03.02.1997
International Patent Classification (IPC) or national classification and IPC H02K 15/085		
Applicant ASEA BROWN BOVERI AB et al		

<p>1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of <u>3</u> sheets, including this cover sheet.</p> <p><input type="checkbox"/> This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).</p> <p>These annexes consist of a total of _____ sheets.</p>
<p>3. This report contains indications relating to the following items:</p> <p>I <input checked="" type="checkbox"/> Basis of the report</p> <p>II <input type="checkbox"/> Priority</p> <p>III <input type="checkbox"/> Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p>IV <input type="checkbox"/> Lack of unity of invention</p> <p>V <input checked="" type="checkbox"/> Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability, citations and explanations supporting such statement</p> <p>VI <input type="checkbox"/> Certain documents cited</p> <p>VII <input type="checkbox"/> Certain defects in the international application</p> <p>VIII <input type="checkbox"/> Certain observations on the international application</p>

Date of submission of the demand 31.08.1998	Date of completion of this report 05.05.1999
Name and mailing address of the IPEA/SE	Authorized officer

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE98/00170

I. Basis of the report



the description, pages _____, as originally filed,

pages _____, filed with the demand,

pages _____, filed with the letter of _____,

pages _____, filed with the letter of _____.



the claims, Nos. _____, as originally filed,

Nos. _____, as amended under Article 19,

Nos. _____, filed with the demand,

Nos. _____, filed with the letter of _____,

Nos. _____, filed with the letter of _____.



the drawings, sheets/fig _____, as originally filed,

sheets/fig _____, filed with the demand

sheets/fig _____, filed with the letter of _____,

sheets/fig _____, filed with the letter of _____.

2. The amendments have resulted in the cancellation of:



the description, pages _____



the claims, Nos. _____



the drawings, sheets/fig _____

3. ☐

This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the supplemental Box (Rule 70.2(c)).

4. Additional observations, if necessary:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE98/00170

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

	Claims		NO
Inventive step (IS)	Claims	1-21	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-21	YES
	Claims		NO

2. Citations and explanations

The invention relates to a rotating electric machine comprising a stator with windings drawn through slots in the stator and a method for manufacturing such a machine. According to the invention the windings consist of high-voltage cable and to prevent damage to the cable during drawing through the slots and during operation the slots are at the end surface provided with cuff means extending axially a short distance into the slots.

Documents cited in the International Search Report:

US 3130335
US 3943392
DE 4023903
US 5036165
US 4853565
US 4510077
SU 955369

The prior art documents disclose rotating electric machines comprising a stator having slots for the windings. The slots are provided with linings. However, none of the documents shows a rotating electric machine with windings consisting of high-voltage cable drawn through the slots and the slots being provided with a cuff at the end surface as defined in the claims. Since there is no teaching in the prior art that would lead a skilled person to the invention, the claimed invention is not considered obvious.

Accordingly, the claimed invention is novel and

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/00170

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: H02K 15/085 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC6: H02K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
WPI		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3130335 A (L.J.REJDA), 21 April 1964 (21.04.64), figure 2 --	1-21
A	US 3943392 A (J.J.KEUPER ET AL), 9 March 1976 (09.03.76), abstract --	1-21
A	DE 4023903 C1 (PIUR, ARMIN), 7 November 1991 (07.11.91), abstract --	1-21
A	US 5036165 A (R.K.ELTON ET AL), 30 July 1991 (30.07.91), figure 1, abstract --	11-18
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
14 July 1998		16-07-1998
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86		Authorized officer Anna Theander Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/00170

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4853565 A (R.ELTON ET AL), 1 August 1989 (01.08.89), column 3, line 50 - line 61; column 7, line 12 - line 37, figures 1,7 --	11-18
A	US 4510077 A (R.ELTON), 9 April 1985 (09.04.85), abstract --	11-18
A	SU 955369 A (KARPOV), 30 August 1982 (30.08.82), figures 1,2, abstract -- -----	4

INTERNATIONAL SEARCH REPORT
Information on patent family members

30/06/98

International application No.
PCT/SE 98/00170

Patent document cited in search report			Publication date	Patent family member(s)	Publication date
US	3130335	A	21/04/64	NONE	
US	3943392	A	09/03/76	CA 1033396 A DE 2550806 A,C FR 2293097 A,B GB 1502845 A JP 51077803 A SE 415718 B,C SE 7512458 A	20/06/78 12/08/76 25/06/76 01/03/78 06/07/76 20/10/80 28/05/76
DE	4023903	C1	07/11/91	CH 683049 A	31/12/93
US	5036165	A	30/07/91	US 5066881 A US 5067046 A CA 1245270 A US 4853565 A	19/11/91 19/11/91 22/11/88 01/08/89
US	4853565	A	01/08/89	CA 1245270 A US 5036165 A US 5066881 A US 5067046 A	22/11/88 30/07/91 19/11/91 19/11/91
US	4510077	A	09/04/85	CH 664646 A,B DE 3439093 A,C FR 2554456 A,B GB 2148880 A,B JP 1789646 C JP 4078576 B JP 60131853 A	15/03/88 15/05/85 10/05/85 05/06/85 29/09/93 11/12/92 13/07/85
SU	955369	A	30/08/82	NONE	

PATENT COOPERATION TREATY

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INTERNATIONAL-TYPE SEARCH REPORT

(PCT Article 15.5)

5700300-2	SE	1 30 310
Filing date (day/month/year)	(Earliest) Priority Date (day/month/year)	
3 February 1997		
Applicant		
ASEA BROWN BOVERI AB		

Date of request for international-type search	International-type search request No.
3 February 1997	SE 97/00120

This international-type search report has been prepared by this International Searching Authority and is transmitted to the applicant.

This international-type search report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ Certain claims were found unsearchable (See Box I).
2. ☐ Unity of invention is lacking (See Box II).
3. ☐ The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international-type search was carried out on the basis of the sequence listing
 - ☐ filed with the international application.
 - ☐ furnished by the applicant separately from the international application,
 - ☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
 - ☐ transcribed by this Authority.

INTERNATIONAL-TYPE SEARCH REPORT

Search request No.

SE 97/00120

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 15/085

According to International Patent Classification (IPC) or to both national classification and IPC

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3130335 A (L.J. REJDA), 21 April 1964 (21.04.64), figure 2 ---	1-15
A	US 3943392 A (J.J. KEUPER ET AL.), 9 March 1976 (09.03.76), abstract ---	1-15
A	DE 4023903 C1 (PIUR, ARMIN), 7 November 1991 (07.11.91), abstract -----	1-15

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international-type search

Swedish Patent Office

Box 5055, S-102 42 STOCKHOLM

Facsimile No. +46 8 666 02 86

Date of mailing of the international-type search report

Anna Theander

Telephone No. +46 8 782 25 00

INTERNATIONAL-TYPE SEARCH REPORT
Information on patent family members

02/12/97

Search request No.

SE 97/00120

US 3130335 A 21/04/64 NONE

FR 2255057 A,B 29/03/76
GB 1502845 A 01/03/78
JP 51077803 A 06/07/76
SE 415718 B,C 20/10/80
SE 7512458 A 28/05/76

DE 4023903 C1 07/11/91 CH 683049 A 31/12/93

PATENT COOPERATION TREATY

PCT

INTERNATIONAL-TYPE SEARCH REPORT

(PCT Article 15.5)

9700360-2	SE	P 96-310
Filing date (day/month/year) 3 February 1997		(Earliest) Priority Date (day/month/year)
Applicant ASEA BROWN BOVERI AB		

Date of request for international-type search 3 February 1997	International-type search request No. SE 97/00120
--	--

This international-type search report has been prepared by this International Searching Authority and is transmitted to the applicant.

This international-type search report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. ☐ Certain claims were found unsearchable (See Box I).
2. ☐ Unity of invention is lacking (See Box II).
3. ☐ The international application contains disclosure of a nucleotide and/or amino acid sequence listing and the international-type search was carried out on the basis of the sequence listing

☐ filed with the international application.
☐ furnished by the applicant separately from the international application,

☐ but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.

☐ transcribed by this Authority.

PCL XL error

Subsystem: IMAGE

Error: MissingData

Operator: ReadImage

Position: 64

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WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H02K 15/085 8162		(11) International Publication Number: WO 98/34330
A1		(43) International Publication Date: 6 August 1998 (06.08.98)
(21) International Application Number: PCT/SE98/00170 (22) International Filing Date: 2 February 1998 (02.02.98) (30) Priority Data: 9700360-2 3 February 1997 (03.02.97) SE 9704430-9 28 November 1997 (28.11.97) SE (71) Applicant (for all designated States except US): ASEA BROWN BOVERI AB [SE/SE]; S-721 83 Västerås (SE). (72) Inventors; and (75) Inventors/Applicants (for US only): HOLMSTRÖM, Göran [SE/SE]; Tistelvägen 22 G, S-191 63 Sollentuna (SE). GÖRAN, Bengt [SE/SE]; Vales väg 13, S-723 55 Västerås (SE). LEIJON, Mats [SE/SE]; Hyvlargatan 5, S-723 35 Västerås (SE). (74) Agent: KARLSSON, Leif; L.A. Groth & Co. KB, P.O. Box 6107, S-102 32 Stockholm (SE).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: A ROTATING ELECTRIC MACHINE AND METHOD OF MANUFACTURING SUCH A MACHINE		
(57) Abstract <p>The present invention relates to a rotating electric machine incorporating a stator (1) with windings drawn through slots (5) in the stator. According to the invention the windings consist of high-voltage cable (6) wherein the slots (5) close to the end plane (19) of the stator are provided with cuff members (13, 16) arranged between the cable (6) in the slot and the walls of each slot (5). A method is also revealed for manufacturing such rotating electric machines in which cuffs are applied in the slots close to the end plane of the stator, after which the cables are drawn through them.</p>		
<p>The diagram is a cross-sectional view of a stator assembly. It shows three vertical slots (5) arranged around a central axis. Each slot contains a high-voltage cable (6). Near the top and bottom of each slot, there are cuff members (13, 16) that appear to hold the cable in place. The stator core is labeled with '1' and '20'. The slots are labeled with '5'. The cables are labeled with '6'. The cuff members are labeled with '13' and '16'. The diagram is also labeled with Roman numerals 'III' at the top and bottom, and Arabic numerals '15' and '14' on the right side.</p>		

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

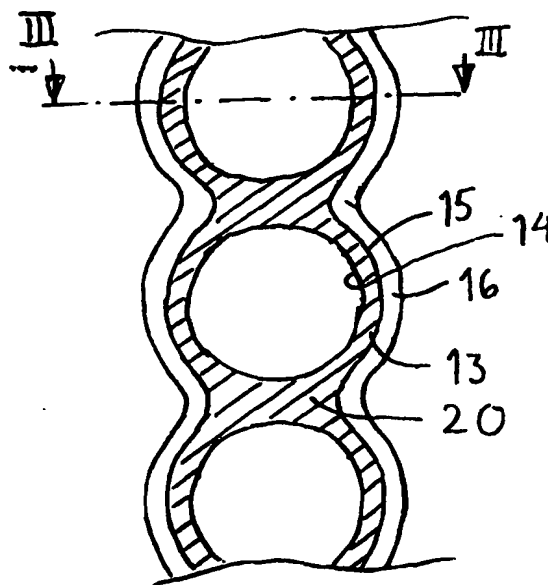


INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H02K 15/085	A1	(11) International Publication Number: WO 98/34330 (43) International Publication Date: 6 August 1998 (06.08.98)
(21) International Application Number: PCT/SE98/00170 (22) International Filing Date: 2 February 1998 (02.02.98) (30) Priority Data: 9700360-2 3 February 1997 (03.02.97) SE 9704430-9 28 November 1997 (28.11.97) SE (71) Applicant (for all designated States except US): ASEA BROWN BOVERI AB [SE/SE]; S-721 83 Västerås (SE). (72) Inventors; and (75) Inventors/Applicants (for US only): HOLMSTRÖM, Göran [SE/SE]; Tistelvägen 22 G, S-191 63 Sollentuna (SE). GÖRAN, Bengt [SE/SE]; Vales väg 13, S-723 55 Västerås (SE). LEIJON, Mats [SE/SE]; Hyvlargatan 5, S-723 35 Västerås (SE). (74) Agent: KARLSSON, Leif; L.A. Groth & Co. KB, P.O. Box 6107, S-102 32 Stockholm (SE).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, FI (Utility model), GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: A ROTATING ELECTRIC MACHINE AND METHOD OF MANUFACTURING SUCH A MACHINE**(57) Abstract**

The present invention relates to a rotating electric machine incorporating a stator (1) with windings drawn through slots (5) in the stator. According to the invention the windings consist of high-voltage cable (6) wherein the slots (5) close to the end plane (19) of the stator are provided with cuff members (13, 16) arranged between the cable (6) in the slot and the walls of each slot (5). A method is also revealed for manufacturing such rotating electric machines in which cuffs are applied in the slots close to the end plane of the stator, after which the cables are drawn through them.



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A ROTATING ELECTRIC MACHINE AND METHOD OF MANUFACTURING
SUCH A MACHINE

5 In a first aspect the present invention relates to a
rotating electric machine of the type described in the
preamble to claim 1, such as synchronous machines and
normal asynchronous machines as well as dual-fed machi-
nes, applications in asynchronous static current con-
10 verter cascades, outer pole machines and synchronous
flow machines.

In a second aspect the invention relates to a method of
the type described in the preamble to claim 13.

15 In the present application the terms "radial", "axial"
and "peripheral" constitute indications of direction
defined in relation to the stator of the machine unless
expressly stated otherwise. The term "cable lead-
through" refers in the application to each individual
20 length of the cable extending through a slot.

The machine is intended primarily as generator in a
power station for generating electric power. The ma-
chine is intended for use at high voltages. High vol-
25 tages shall be understood here to mean electric volta-
ges in excess of 10 kV. A typical operating range for
the machine according to the invention may be 36 to
800 kV.

30 Similar machines have conventionally been designed for
voltages in the range 6-30 kV, and 30 kV has normally
been considered to be an upper limit. This generally
means that a generator must be connected to the power
network via a transformer which steps up the voltage to

the level of the power network, i.e. in the range of approximately 100-400 kV.

Although the predominant technology when supplying current to a high-voltage network for transmission, sub-transmission and distribution, is to insert a transformer between the generator and the power network as mentioned in the introduction, it is already known to endeavour to eliminate the transformer by generating the voltage directly at the level of the network. Such a generator is described in US-4 429 244, US-4 164 672 and US-3 743 867.

A conductor is known through US-5,036,165, in which the insulation is provided with an inner and an outer layer of semiconducting pyrolyzed glassfiber. It is also known to provide conductors in a dynamo-electric machine with such an insulation, as described in US-5,066,881 for instance, where a semiconducting pyrolyzed glassfiber layer is in contact with the two parallel rods forming the conductor, and the insulation in the stator slots is surrounded by an outer layer of semiconducting pyrolyzed glassfiber. The pyrolyzed glassfiber material is described as suitable since it retains its resistivity even after the impregnation treatment.

By using high-voltage insulated electric conductors, in the following termed cables, with solid insulation similar to that used in cables for transmitting electric power in the stator winding (e.g. XLPE cables) the voltage of the machine can be increased to such levels that it can be connected directly to the power network without an intermediate transformer.

The concept generally requires the slots in which the cables are placed in the stator to be deeper than with conventional technology (thicker insulation due to higher voltage and more turns in the winding). This entails new problems with regard to cooling, vibrations and natural frequencies in the region of the coil end, teeth and winding.

Securing the cable in the slot is also a problem - the cable must be inserted into the slot without its outer layer being damaged. The cable is subjected to currents having a frequency of 100 Hz which cause a tendency to vibration and, besides manufacturing tolerances with regard to the outer diameter, its dimensions will also vary with variations in temperature (i.e. load variations).

The present invention relates to the above-mentioned problems associated with avoiding damage to the exterior of the cable during insertion into the stator slots and avoiding wear against the surface caused by vibration during operation. There is particular risk of damage at the insertion point where the cable may be damaged against the edge between the slot and the end surface of the stator. The cable may also be damaged if it is inserted askew or eccentrically in the slot. Even during operation there is risk of damage where the cable passes the end surface of the stator. Especially in the event of angle or centring errors, said edge may rub against the outer semiconducting layer of the cable, due to the relative rigidity of the cable, thereby damaging it.

Against this background, the object of the present invention is to eliminate or at least reduce the risk of damage to the cable where it exits at the end surface

of the stator in a rotating electric machine capable of working in the high voltage range.

5 According to a first aspect of the invention this is achieved by providing a rotating electric machine of the type described in the preamble to claim 1 with the special features defined in the characterizing part of this claim.

10 Such cuff means reduces the risk of damage when the cable is wound since the cuff prevents the outer semi-conducting layer from coming into contact with the edge of the slot wall at its insertion, and also ensures that the cable is guided into the slot centrally and
15 straight. The risk of damage during operation is also reduced since the cuff can be made of a softer material than the stator and therefore acts as pressure equalizer.

20 In one preferred embodiment the cuff means extends in radial direction over a plurality of cable lead-throughs, preferably all cable lead-throughs in the slot, and has a profile corresponding to the profile of the slot. This provides stable and reliable securing.

25 The advantages of the invention are particularly significant when the slots have alternating wide and narrow parts, their profiles therefore resembling a bicycle chain, since the slot wall then surrounds a relatively
30 large part of each cable lead-through. A machine having such slot profile thus constitutes a preferred embodiment.

35 It is advantageous to make the cuff means of an elastic material. This should be free from process oil and may suitably be silicon rubber. The elasticity of the ma-

terial facilitates guiding the cable and to a great extent exploits the opportunity of achieving pressure equalization at the exit points.

- 5 In another preferred embodiment the cuff means is provided at its inner end with a collar protruding into a recess in the slot. This offers a simple and economical way of applying the cuff and achieves reliable retention of the cuff in the slot.

10

- With a view to facilitating insertion of the cable, the inner profile of the cuff preferably widens somewhat towards the end plane of the stator. This also contributes to a gentle exit of the cable, thereby further
15 reducing the risk of damage during operation.

- In a further preferred embodiment the cuff means is arranged to seal against both cable and slot wall. A sealed space is thus formed inside the slot which can be
20 filled with support compound sprayed into the slot and solidified therein. In some cases this may be an expedient manner of supporting the cable in the slot.

- The invention is in the first place intended for use
25 with a high-voltage cable of the type built up of an inner core having a plurality of strand parts, an inner semiconducting layer, an insulating layer surrounding this, and an outer semiconducting layer the latter, and its advantages are particularly marked here. The in-
30 vention refers particularly to such a cable having a diameter within the interval 20-200 mm and a conducting area within the interval 80-3000 mm².

- In the arrangement according to the invention the windings are preferably of a type corresponding to cables
35 with solid, extruded insulation, such as those used

nowadays for power distribution, e.g. XLPE-cables or cables with EPR-insulation. Such a cable comprises an inner conductor composed of one or more strand parts, an inner semiconducting layer surrounding the conductor, a solid insulating layer surrounding this and an outer semiconducting layer surrounding the insulating layer. Such cables are flexible, which is an important property in this context since the technology for the device according to the invention is based primarily on winding systems in which the winding is formed from cable which is bent during assembly. The flexibility of a XLPE-cable normally corresponds to a radius of curvature of approximately 20 cm for a cable 30 mm in diameter, and a radius of curvature of approximately 65 cm for a cable 80 mm in diameter. In the present application the term "flexible" is used to indicate that the winding is flexible down to a radius of curvature in the order of four times the cable diameter, preferably eight to twelve times the cable diameter.

The winding should preferably be constructed to retain its properties even when it is bent and when it is subjected to thermal stress during operation. It is vital that the layers retain their adhesion to each other in this context. The material properties of the layers are decisive here, particularly their elasticity and relative coefficients of thermal expansion. In a XLPE-cable, for instance, the insulating layer consists of cross-linked, low-density polyethylene, and the semiconducting layers consist of polyethylene with soot and metal particles mixed in. Changes in volume as a result of temperature fluctuations are completely absorbed as changes in radius in the cable and, thanks to the comparatively slight difference between the coefficients of thermal expansion in the layers in relation to the elasticity of these materials, radial expansion

can take place without the adhesion between the layers being lost.

5 The material combinations stated above should be considered only as examples. Other combinations fulfilling the conditions specified and also the condition of being semiconducting, i.e. having resistivity within the range of 10^{-1} - 10^6 ohm-cm, e.g. 1-500 ohm-cm, or 10-200 ohm-cm, naturally also fall within the scope of
10 the invention.

The insulating layer may consist, for example, of a solid thermoplastic material such as low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), polybutylene (PB), polymethyl pentene (PMP), cross-linked materials such as cross-linked polyethylene (XLPE), or rubber such as ethylene propylene rubber (EPR) or silicon rubber.

20 The inner and outer semiconducting layers may be of the same basic material but with particles of conducting material such as soot or metal powder mixed in.

The mechanical properties of these materials, particularly their coefficients of thermal expansion, are affected relatively little by whether soot or metal powder is mixed in or not - at least in the proportions required to achieve the conductivity necessary according to the invention. The insulating layer and the
30 semiconducting layers thus have substantially the same coefficients of thermal expansion.

Ethylene-vinyl-acetate copolymers/nitrile rubber, butyl graft polyethylene, ethylene-butyl-acrylate-copolymers
35 and ethylene-ethyl-acrylate copolymers may also constitute suitable polymers for the semiconducting layers.

Even when different types of material are used as base in the various layers, it is desirable for their coefficients of thermal expansion to be substantially the same. This is the case with combination of the materials listed above.

The materials listed above have relatively good elasticity, with an E-modulus of $E < 500$ MPa, preferably < 200 MPa. The elasticity is sufficient for any minor differences between the coefficients of thermal expansion for the materials in the layers to be absorbed in the radial direction of the elasticity so that no cracks appear, or any other damage, and so that the layers are not released from each other. The material in the layers is elastic, and the adhesion between the layers is at least of the same magnitude as the weakest of the materials.

The conductivity of the two semiconducting layers is sufficient to substantially equalize the potential along each layer. The conductivity of the outer semiconducting layer is sufficiently great to enclose the electrical field in the cable, but sufficiently small not to give rise to significant losses due to currents induced in the longitudinal direction of the layer.

Thus preferably, each of the two semiconducting layers essentially constitutes one equipotential surface and the winding, with these layers, will substantially enclose the electrical field within it.

There is, of course, nothing to prevent one or more additional semiconducting layers being arranged in the insulating layer.

The application on such cables thus constitutes preferred embodiments of the invention.

5 These and other preferred embodiments of the machine according to the invention are defined in the sub-claims to claim 1.

10 In a second aspect of the invention the object striven for is achieved by a method of manufacturing a rotating electric machine of the type described in the preamble to claim 19 including the specific measures defined in the characterizing part of this claim.

15 According to a preferred embodiment of the method the cuff means are lubricated with an anti-friction agent, thereby facilitating drawing the cable through them and also reducing the risk of it being damaged during this operation.

20 Cuff means in accordance with the preferred embodiments of the machine are used in other preferred embodiments of the method according to the invention.

25 The invention will now be explained in more detail in the following description of a preferred embodiment, with reference to the accompanying drawings in which

Figure 1 shows a schematic end view of a sector of the stator in a machine according to the invention,
30 Figure 2 shows a cross section through a cable used in the machine according to the invention,
Figure 3 shows a part section along the line III-III in Figure 2,
Figure 4 shows a part section along the line IV-IV in
35 Figure 3.

In the schematic axial view shown in Figure 1 through a sector of the stator 1 of the machine, its rotor is designated 2. The stator is conventionally composed of a laminated core of core sheet. The figure shows a sector of the machine corresponding to one pole division. From a yoke part 3 of the core, situated radially outermost, a number of teeth 4 extend radially inwards towards the rotor 2, the teeth being separated by slots 5 in which the stator winding is arranged. The cables 6 in the windings are high-voltage cables and may be of substantially the same type of high-voltage cables as those used for power distribution, e.g. XLPE cables. One difference is that the outer, mechanically protective sheath and metal screen that normally surround such a cable are omitted. The cable thus consists only of a conductor, an inner semiconducting layer, an insulating layer and an outer semiconducting layer. The semiconducting layer sensitive to mechanical damage on the outside of the cable is thus exposed.

In the figure the cables 6 are indicated schematically, only the central, conducting part of the cable part or coil side being drawn in. As can be seen, each slot 5 has varying cross section with alternating wide parts 7 and narrow parts 8. The wide parts 7 are substantially circular and surround the cable lead-throughs, the waist parts between these thus forming narrow parts 8. The waist parts serve to radially position each cable lead-through. The cross section of the slot as a whole also becomes narrower radially inwards. This is because the voltage in the cable lead-throughs is lower the closer they are situated to the radially innermost part of the stator. Slim cable lead-throughs can therefore be used here, whereas thicker ones are necessary further out. Cables of three different dimensions are used

in the example illustrated, arranged in three sections 9, 10, 11 of the slot 5 dimensioned to fit them.

Figure 2 shows a cross section through a high-voltage cable 6 used according to the present invention. The high-voltage cable 6 a number of strand parts 31 made of copper (Cu), for instance, and having circular cross section. These strand parts 31 are arranged in the middle of the cable 6. Around the strand parts 31 is a first semiconducting layer 32. Around the first semiconducting layer 32 is an insulating layer 33, e.g. XLPE-insulation, and around the insulating layer 33 is a second semiconducting layer 34. The concept of "high-voltage cable" in the present application need not therefore include the metal screen and the outer sheath that normally surround such a cable for power distribution.

Figure 3 shows a cross section through a cuff according to the invention. The section is taken along the line III-III in Figure 1 and extends a short way in from one end surface of the stator 1. The external shape 15 of the cuff corresponds to that of the slot 5, i.e. similar to a bicycle chain, where the section runs laterally through one of the wide parts of the "bicycle chain", as shown in Figure 4 where the position of the section in Figure 3 is also indicated. The cuff is arranged close to one end 19 of the stator 1 and a similar cuff is arranged at the opposite end of the stator. The cuff extends radially along the entire slot 5 and each slot is provided with such a cuff. The axial extension of the cuff is approximately 4 cm and normally lies within the interval 2-6 cm. The laminated core of the stator is designated 18 and an end plate 12 of fiber material is arranged at its ends. The cuff is incorporated in the end plate 12. A recess 17 is provi-

ded in the part of the slot 5 extending through the end plate. The recess runs in the slot wall along the entire radial length of the slot 5. The cuff is provided with a collar 16 fitting into the recess 17. From the collar 16 the lining part 13 of the cuff stretches out towards the end surface 19 of the stator and terminates immediately prior to this. The cuff may alternatively terminate on a level with the end surface of the stator, or extend a short way outside this. The lining 13 of the cuff tightly abuts the slot wall along its entire length.

The inside 14 of the cuff widens slightly towards the end surface 19 of the stator, at an angle of a few degrees. The inside of the cuff is thus slightly conical at the areas around the cable lead-throughs. Where the cuff is to receive the cable 6, its smallest inner diameter close to the collar may correspond approximately to the outer diameter of the cable 6, or may be somewhat less to ensure good sealing and efficient support. The cuff is made of an elastic material, suitably silicon rubber. It is important that the material does not contain any remnants of process oil since this can diffuse in towards the outer semiconducting layer 34 of the cable, attacking and damaging this. The material should also be thermally stable.

Between the cable positions in the cuff, i.e. in the narrower parts, the cuff has waist portions 20, (see Figure 4) that fill out the slot at these points, ensuring that it is completely sealed.

When the cuffs are fitted, which is performed before the stator is wound, they are squeezed together and pushed axially into the slot 5 until the collar 16 of the cuff snaps into the recess 17 in the slot, and it

is thus locked in place. When the cuffs have been applied the cable can be wound, the cuffs functioning as guides. The cable is thus correctly guided and prevented from coming into contact with the edge between the slot and the end surface of the stator, thereby eliminating risk of damage. It may be advisable to lubricate the inside of the cuff to facilitate insertion of the cable. A lubricant should be selected which does not influence the outer semiconducting layer of the cable. Suitable lubricants are talcum or boron nitride.

The cuff described above extends in radial direction along the entire slot. Alternatively an individual cuff may be arranged for each cable lead-through and is in that case cylindrical. The invention does not exclude other alternatives for securing the cuffs than by means of the collar described. They can be glued to the slot, for instance, or retained solely by friction.

CLAIMS

1. A rotating electric machine incorporating a stator (1) with windings drawn through slots (5) in the stator, **characterized** in that the windings consist of high-voltage cable (6) and in that at least one of said slots (5) at at least one end surface of the stator (1) is provided with cuff means (13, 16) arranged between the cable (6) and the slot (5), said cuff means extending axially a short distance into the slot.
2. A rotating electric machine as claimed in claim 1, wherein said cuff means (13, 16) comprises a cuff extending in radial direction over a plurality of cable lead-throughs, preferably all of them, and having a profile in radial section that substantially corresponds with the profile of the slot.
3. A rotating electric machine as claimed in claim 1 or 2, wherein said cuff means comprises a plurality of cuffs, circular in a radial section, each cuff surrounding a cable lead-through.
4. A rotating electric machine as claimed in any of claims 1-3, wherein the slot has a profile that, in a radial section, has wide parts (7) and narrow parts (8).
5. A rotating electric machine as claimed in any of claims 1-4, wherein the cuff means (13, 16) is made of an elastic material.
6. A rotating electric machine as claimed in claim 5, wherein said material is free from oil and preferably consists of silicon rubber.

7. A rotating electric machine as claimed in any of claims 1-6, wherein the cuff means (13, 16) has an axial extension of 2-6 cm and its axially outermost end is situated immediately inside the end surface (19) of the stator.

8. A rotating electric machine as claimed in any of claims 1-7, wherein the cuff means (13, 16) is provided at its axially innermost end with a collar (16) protruding into a recess (17) running in a radial plane in the walls of the slot.

9. A rotating electric machine as claimed in any of claims 1-8, wherein the cuff means (13, 16) around each cable lead-through has an inner profile (14) with a least diameter corresponding substantially to the outer diameter of the cable (6) and expanding conically towards the end plane (19) of the stator.

10. A rotating electric machine as claimed in any of claims 1-9, wherein the cuff means (13, 16) is arranged to abut sealingly against both slot wall (5) and cable (6).

11. A rotating electric machine as claimed in any of claims 1-10, wherein the cable (6) is of a type comprising a core with a plurality of strand parts (31), an inner semiconducting layer (32) surrounding the core, an insulating layer (33) surrounding the inner semiconducting layer, and an outer semiconducting layer (34) surrounding the insulating layer (33).

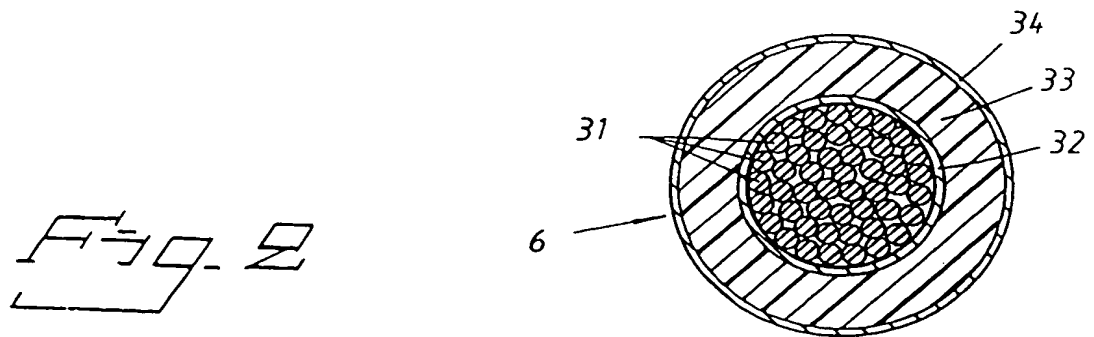
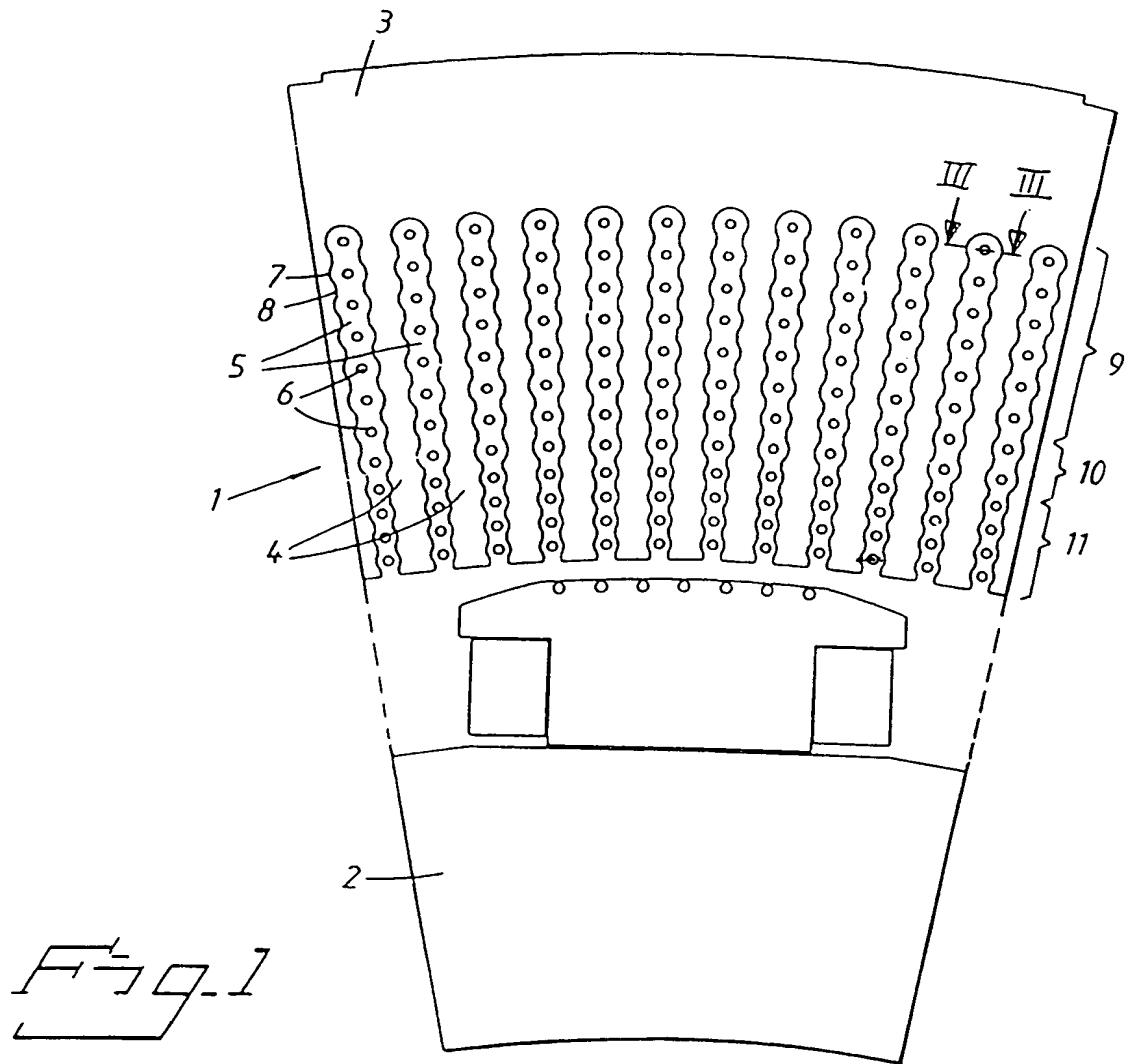
12. A rotating electric machine as claimed in claim 11, wherein the high-voltage cable (6) has a diameter within the interval 20-200 mm and a conducting area within the interval 80-3000 mm².

13. A rotating electric machine as claimed in claims 11 or 12, wherein the winding is flexible and in that said layers are in contact with each other.
- 5 14. A rotating electric machine as claimed in claim 13, **characterized** in that said layers consist of materials with such elasticity and such a relation between the coefficients of thermal expansion of the materials that the changes in volume in the layers caused by tem-
10 perature fluctuations during operation are absorbed by the elasticity of the materials so that the layers retain their adhesion to each other at the temperature fluctuations occurring during operation.
- 15 15. A rotating electric machine as claimed in claim 13 or claim 14, wherein the materials in said layers have high elasticity, preferably with an E-modulus less than 500 MPa, most preferably less than 200 MPa.
- 20 16. A rotating electric machine as claimed in any of claims 13-15, wherein the coefficients of thermal expansion for the materials in said layers are of substantially the same magnitude.
- 25 17. A rotating electric machine as claimed in any of claims 13-16, wherein the adhesion between the layers is of at least the same magnitude as in the weakest of the materials.
- 30 18. A rotating electric machine as claimed in any of claims 13-17, wherein each of the semiconducting layers essentially constitutes one equipotential surface.
- 35 19. A method of manufacturing a rotating electric machine incorporating a stator with windings drawn

through slots in the stator, **characterized** in that the machine is wound with high-voltage cable and cuff means are applied in at least one of said slots at at least one end surface of the stator, so that the cuff means extend a short distance into the slot, the inner dimensions of said cuff means permitting passage of the cable, after which the cable is wound in the slots through the cuff means.

10 20. A method as claimed in claim 19, wherein the cuff means is lubricated with an anti-friction agent before the cable is passed through them.

15 21. A method as claimed in claim 19 or claim 20, wherein the cuff means applied is in accordance with the embodiments defined in any of claims 1-10.



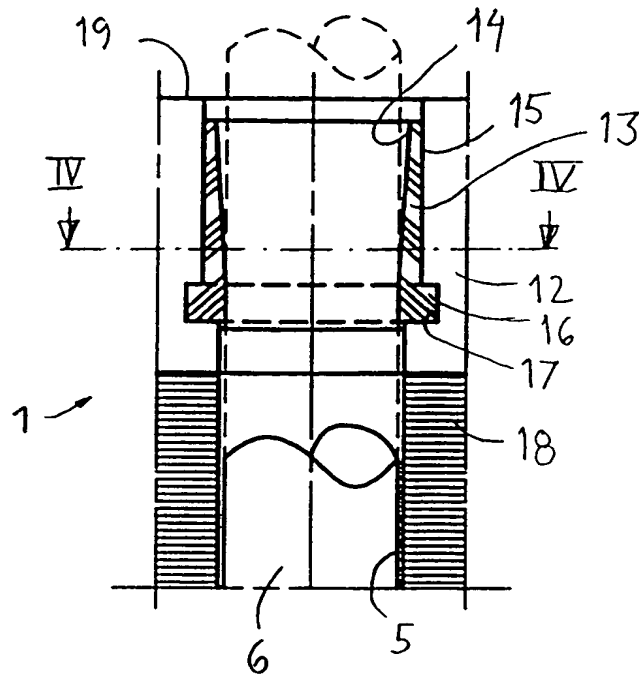


Fig. 3

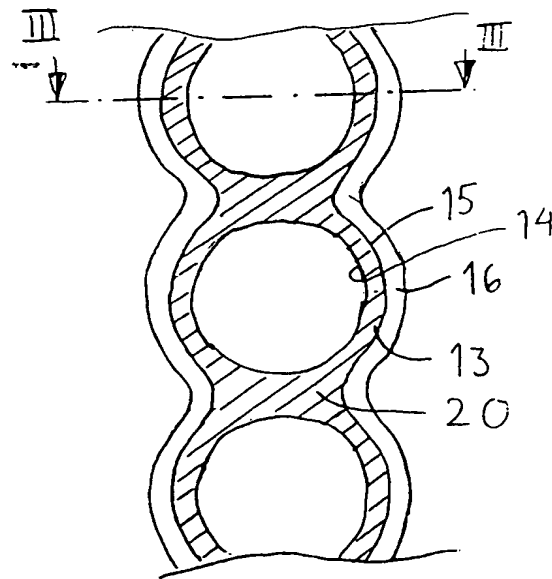


Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/00170

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02K 15/085

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3130335 A (L.J.REJDA), 21 April 1964 (21.04.64), figure 2 --	1-21
A	US 3943392 A (J.J.KEUPER ET AL), 9 March 1976 (09.03.76), abstract --	1-21
A	DE 4023903 C1 (PIUR, ARMIN), 7 November 1991 (07.11.91), abstract --	1-21
A	US 5036165 A (R.K.ELTON ET AL), 30 July 1991 (30.07.91), figure 1, abstract --	11-18

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4853565 A (R.ELTON ET AL), 1 August 1989 (01.08.89), column 3, line 50 - line 61; column 7, line 12 - line 37, figures 1,7 --	11-18
A	US 4510077 A (R.ELTON), 9 April 1985 (09.04.85), abstract --	11-18
A	SU 955369 A (KARPOV), 30 August 1982 (30.08.82), figures 1,2, abstract -- -----	4

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/06/98

International application No.

PCT/SE 98/00170

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